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WATER SUPPLY AND WATER QUALITY CONTROL STUDY PAPILLION CREEK BASIN, NEBRASKA. STUDY OF THE NEEDS AND VALUE OF STORAGE FOR MUNICIPAL AND INDUSTRIAL WATER SUPPLY AND WATER QUALITY CONTROL

Federal Water Pollution Control Administration
Kansas City, Missouri

October 1966

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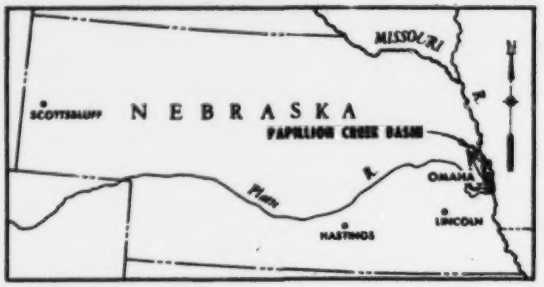
WATER SUPPLY AND WATER QUALITY CONTROL STUDY PAPILLION CREEK BASIN NEBRASKA

Study of the Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control



UNITED STATES
DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Kansas City, Missouri
October 1966

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P19 Water Supply and Water Quality Control Study
Papillion Creek Basin Nebraska.

FWPCA Kansas City, Missouri October 1966

(no ac # in m.c)

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

PAPILLION CREEK BASIN
NEBRASKA

A survey has been made which discloses no need for storage for municipal and industrial water supplies and an immediate need for storage for streamflow regulation for the purpose of water quality control. These conclusions are based on results of engineering, economic, and demographic studies. The future needs are based on projected population and industrial growth.

Prepared for

DEPARTMENT OF THE ARMY

U. S. Army Engineer District

Omaha, Nebraska

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Kansas City, Missouri
October 1966

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Exhibit No.	
1	Municipal Water Supplies
2	Chemical Analyses of Water Supplies
3	Basic Data on Sources of Pollution

I. INTRODUCTION

Request and Authority

In a letter dated November 5, 1965, the U. S. Army Engineer District, Omaha, Nebraska, requested the advice of the U. S. Department of Health, Education and Welfare concerning the needs for storage for water supply and water quality control in the Papillion Creek Basin near Omaha, Nebraska, and the value of the benefits resulting therefrom.

The water supply portion of this study was made in accordance with the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education and Welfare, relative to the Water Supply Act of 1958, as amended (43 U.S.C. 390b). The water quality control aspects are considered under authority of the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.). The responsibility for these activities was transferred from the Department of Health, Education and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

Purpose and Scope

The purpose of this study is to determine the need for and value of storage for municipal and industrial water supply and water quality control in the Papillion Creek Basin. Papillion Creek and its tributaries drain an area of 394 square miles in Washington, Douglas and Sarpy Counties, located in eastern Nebraska. The study covers a 100 year period, 1970 to 2070, as requested by the Corps of Engineers.

Acknowledgments

The cooperation and assistance of many persons and agencies are gratefully acknowledged. Special appreciation is expressed to the following:

U. S. Army Engineers, Omaha District Corps of Engineers

Department of Water Resources, Lincoln, Nebraska

Nebraska Department of Health, Lincoln, Nebraska

Conservation and Survey Division, University of Nebraska, Lincoln, Nebraska

U. S. Geological Survey, Lincoln, Nebraska

Papio Watershed Advisory Board, Omaha, Nebraska

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Corps of Engineers is making a study of the feasibility of constructing multipurpose reservoirs for flood control, recreation, water supply and water quality control in the Papillion Creek Basin in Nebraska.

2. The study area under consideration is the 394 square mile Papillion Creek Basin located in eastern Nebraska in the counties of Washington, Douglas and Sarpy.

3. The 1960 population of the basin was approximately 183,000, of which approximately 180,000 were located in the Omaha metropolitan area.

4. The municipal and industrial water supplies are served from the Missouri River through the Omaha Municipal Utilities District and through other municipal or privately owned wells.

5. Average daily municipal and industrial use of water supplied by the Omaha Municipal Utilities District is 188 gallons per capita. The per capita use of communities in the basin not served by the District, range from 51 gallons per capita per day to 130 gallons per capita per day.

6. At present wastes totalling approximately 17,000 P.E. are discharged into Papillion Creek and its tributaries.

Conclusions

1. The population of the basin is expected to increase from a

present population of approximately 200,000 to 343,000 in 1980, 810,000 in 2020 and 2,400,000 in 2070. Most of this growth is expected in the counties of Douglas and Sarpy in the middle and lower portions of the basin.

2. The municipal and industrial water needs are expected to increase to approximately 360 mgd in 2070.

3. It is expected that the municipal and industrial water needs can continue to be met by the present sources, and no benefit would be obtained by providing storage for this purpose.

4. It is expected that wastes produced in the heavily urbanized middle and lower portions of the basin will eventually be intercepted, treated and discharged to the Missouri River. It is not considered feasible to construct reservoirs in the basin of sufficient size to supply the amount of water necessary to adequately dilute all of the wastes.

5. Proposed streamflow regulation to minimize the effects of urban runoff and to dilute small amounts of remaining wastes would maintain and enhance the recreational and esthetic enjoyment of Papillion Creek and its tributaries as they pass through parks and extensive residential areas.

6. An annual draft on storage of 1,080 acre-feet at the Irvington site, 1,680 acre-feet at the West Dodge site and 600 acre-feet at the County Line will be needed by 2070. The year of first need is 1970. The most economical method of control and, therefore,

the most likely alternative is pumping ground water at each site for dilution. The total annual benefit is estimated to be $10,400. The annual benefit is $3,300 at County Line, $3,400 at Irvington and $3,700 at West Dodge. The figures, based on cost of facilities provided by the Omaha District Office, Corps of Engineers, include amortization of the initial investments at 3-1/8 percent for 100 years, operation and maintenance, energy and replacement costs.

7. These conclusions are based on the best data available but are subject to revision as field data from the Missouri-Souris-Red River Basins Comprehensive Water Pollution Control Project become available.

III. PROJECT DESCRIPTION

Location

The proposed projects are located on Papillion Creek and its tributaries in Washington, Douglas and Sarpy Counties, Nebraska, as shown on the location map. (Figure X-1)

Pertinent Data

Eight reservoir sites, controlling runoff from approximately 145 square miles in the basin, are under consideration by the Corps of Engineers. Table No. III-1 shows the approximate locations and drainage area at the dam sites.

Table III-1

Reservoir Data
Papillion Creek Basin
(Nebraska)

Reservoir	Location	Drainage Area Square Miles
Irvington	Little Papillion Creek one-half mile North of Irvington	19.0
Washington	Big Papillion Cr. 1 mile Southeast of Washington	11.4
Kennard East	Big Papillion Cr. 1 mile East of Kennard	18.2
Kennard West	Big Papillion Cr. 1 mile West of Kennard	16.8
West Dodge	North Branch Papillion Cr. 4½ miles Northwest of Millard	14.0
Millard	Box Elder Cr. 2 miles North of Millard	16.7
Chalco	West Papillion Branch Cr. 5 miles West of Papillion	13.8
County Line	Main Stem Papillion Creek 1 mile East of Washington	35

IV. STUDY AREA DESCRIPTION

The Papillion Basin is located in eastern Nebraska. The basin has a width of 12 miles, a length of 41 miles and a drainage area of 394 square miles. Principal tributaries are Big Papillion Creek, Little Papillion Creek and the West Branch. The Big and Little Papillion Creeks unite south of the City of Omaha to form Papillion Creek and the West Branch enters a short distance above Offutt Air Force Base. The areas drained by Little and Big Papillion Creeks and the West Branch are 60 square miles, 205 square miles and 129 square miles, respectively.

Metropolitan Omaha encompasses the middle and lower portions of the basin in Douglas and Sarpy Counties, while the remainder of the basin is primarily rural in nature. Offutt Air Force Base and the small towns of Papillion, Millard, Elkhorn, Ralston, Irvington, Bennington, Kennard and Washington are located in the basin as shown on Figure X-1.

Topography

The basin is characterized by deep narrow valleys with steep valley slopes. The valleys slope in a generally southerly direction and have an average fall of 20 feet per mile above the confluence of Little and Big Papillion Creeks and three feet per mile below this point. The valley widths aver[illegible] about 1,000 to 1,500 feet in the upper reaches, extending to one mile in some areas in the lower basin.

Geologic and Soil Characteristics

The Papillion Creek drainage system flows through the disected till plains of eastern Nebraska, a section chiefly occupied by hills formed in glacial drift. All the sediments were laid down since glacial or Pleistocene period. Surface material include glacial debris dropped by ice sheets; silts from wind erosion (known as loess deposits); and clays, silts and sand reworked and deposited by streams as alluvium. The glacial drift is a mixture of grayish boulder clay, sand, pebbles and cobbles. In its upper part, it is usually oxydized and altered to a mottled whitish, yellow and rust color. The loess mantels the hills and valley slopes to depths ranging to 80 feet. Its upper one and one-half to two feet constitute a highly productive soil as a result of the addition of organic matter. The alluvium in the stream valleys is composed of a mixture of sediments. Near the surface, the alluvium has been enriched by organic matter to form a good agricultural soil. At lower depths, silty sand and coarse sand lenses may be encountered. Water supplies for most areas outside the Omaha metropolitan area are served by wells penetrating these coarse sand lenses.

Climate

The subhumid climate of the Papillion Creek Basin is typical of the Great Plains Region with warm summers and cold dry winters. Rapid changes in weather are characteristic of the area and are evidenced

by extreme variations in temperature, strong and gusty winds for short periods and intense thunderstorm rainfall. The average annual temperature is 51° F with temperature extremes ranging from -36° F to 116° F. The annual growing season lasts an average of 170 days. The average annual precipitation in the basin is about 28 inches; approximately 75 percent of this total occurs during the growing season, April through September. Annual precipitation has varied from 13.6 inches to 48.9 inches. Intense thunderstorms are common and have produced daily point rainfall amounts in excess of 7 inches in the basin. Snowfall averages about 28 inches per year.6/

V. WATER RESOURCES OF THE STUDY AREA

Surface Water

Streamflow in the Papillion Creek Basin is extremely variable. The basin is subject to periods of high runoff from rather frequent severe thunderstorms and periods of very low flow. A gaging station maintained by the Corps of Engineers located at river mile 7.5 at Fort Crook indicates an average flow of 123 cfs for the 15 year period of record. Daily flows have ranged from 11 cfs to a maximum of 23,238 cfs.

There are no long term chemical quality records of surface water in the basin. A recent analysis at Fort Crook indicated a hardness of 302 mg/1, a sulfate concentration of 79 mg/1 and a chloride concentration of 59 mg/1. This sample was taken under low flow conditions.

Ground Water

Ground water is found in the glacial drift occupying most of the basin. Wells ranging in depths up to 100 feet supply as much as 500 gallons per minute if properly located and constructed. Most of the smaller towns outside the Omaha metropolitan area are served by ground water supplies. Although the ground water is hard, it generally meets the recommended limits prescribed in the U. S. Public Health Service Drinking Water Standards. A summary of the chemical analyses of municipal water supplies is presented in Exhibit No. 2.

VI. ECONOMY AND POPULATION

Present and Future

An assessment of future municipal and industrial and water quality control requirements in the Papillion River Basin involves an appraisal of its industrial and population growth potential.

The study area was defined as the Papillion Creek drainage basin, shown in Figure X-1.

Economic and population studies and projections for the Papillion Creek drainage basin were conducted by the Corps of Engineers, Omaha District. The results of their studies are shown below. In 1980, the entire basin, as part of the Omaha SMSA, was projected to be urban.

Present and Projected Population
Papillion River Basin
1960 - 2070

	1960	1980	2020	2070
STUDY AREA	183,000	343,000	810,000	2,400,000

VII. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

Present Water Use

Although several of the municipalities have wells tapping the shallow ground water supplies, the major part of the municipal and industrial water used in the basin is supplied from the Missouri River through the Omaha Municipal Utilities District. (Exhibit No. 1)

An average of approximately 23 mgd is pumped for municipal and industrial use in the basin of which all but approximately 6 mgd is supplied by the Omaha Municipal Utilities District.3/

Future

The increase in municipal and industrial water supply requirement in the basin during the study period is based on the anticipated population growth, commercialization, and increased per capita use occasioned by a higher standard of living and the continued development of water using devices for the home. The study area is expected to have a steady, light industrial and commercial growth, especially in the middle and lower portions of the basin in the counties of Douglas and Sarpy. There should be no significant expansion of heavy water using industries.

A need of approximately 360 mgd is forecast for the basin for 2070. It is expected that available ground water sources can be expanded to meet part of the need where it is more economical. The needs of most of the Omaha metropolitan area can be met by expansion of the use of the Missouri River.

VIII. WATER QUALITY CONTROL

Municipal, Industrial and Agricultural Pollution

The quality of the water of Papillion Creek and its tributaries has been affected by organic wastes from (1) natural runoff, (2) storm-water overflow from sewers, and (3) municipal and industrial waste treatment plant effluent. These wastes exceed the assimilation capacity of the area streams. With the anticipated population growth, and consequent increase in waste discharge, it will be necessary that most of the waste in the metropolitan area be collected and piped downstream for treatment prior to discharge to the Missouri River.

Data on sources of pollution are presented in Exhibit No. 3 of the Appendix and points of waste discharge are shown schematically on Figure 2.

The present sewage treatment facilities, where adequate, are expected to be used as an interim measure until it is feasible to construct a sewage collection and central treatment system for the metropolitan area. Outside the metropolitan area in the northern part of the basin where little growth is expected, well operated secondary treatment facilities should be adequate throughout the study period.

Water Quality Criteria

The water quality control criteria used in this report are based on the principal uses to which the streams in the basin are expected to be put, namely recreation and fishing.

Concentrations of at least 3-5 mg/l of dissolved oxygen are necessary to maintain native fish and other aquatic life associated with a healthy stream environment. Maintenance of some dissolved oxygen is also essential to prevent nuisance conditions.

Since available data indicate that the mineral quality of Papillion Creek and its tributaries is satisfactory, quality control needs are based on the effect of organic materials in the stream. The effect of organic waste discharge and the hydraulic characteristics of individual streams is reflected in the dissolved oxygen levels. A dissolved oxygen objective of at least 5 mg/l has been selected in this study to maintain fish and aquatic life and to maintain and enhance present and anticipated recreational use of the streams. Maintenance of this objective at the minimum point will assure still higher dissolved oxygen concentrations in most cases.

Flow Regulation

The Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.), provides that consideration be given in the survey or planning of a reservoir by a Federal construction agency to the inclusion of storage for regulation of streamflow for the purpose of controlling water quality. The law expressly states that such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling wastes at their source. For domestic wastes it is considered possible to obtain 85 to 90 percent removal

of BOD with well operated secondary waste treatment plants of adequate capacity. In some cases, additional facilities or treatment have been provided, as for example, extensive interceptor systems in heavily built-up areas or advanced waste treatment where special problems have warranted the greater expense. Secondary treatment has been the upper limit of treatment normally provided, however. Stormwater runoff from urban areas has also been found to obtain organic materials having a BOD totalling up to 8 percent or more of the amount discharged from a residential area on an average annual basis. In heavy storms this waste is diluted in the stream but rainfall of less intensity can carry more waste into the stream than the flow can absorb. This problem is under special study by the Federal Water Pollution Control Administration.

The discharge of waste, even when treated to the maximum extent technically and economically feasible, can cause an unsatisfactory condition in water whose assimilation capacity is exceeded.

Because sufficient storage cannot be supplied for the dilution of adequately treated waste, it will be necessary that most wastes in the metropolition Omaha area be intercepted and treated for discharge into the Missouri River. Flow must be maintained below three of the proposed reservoirs to prevent the adverse effect of urban runoff and to provide adequate dilution for the small amounts of treated waste which will be released to the stream. Based on the expected effects of treated waste and urban runoff on the D. O. in the streams and the

expected development of population patterns, an average release of 3 cfs from each of the projects, (1) Irvington, (2) County Line, and (3) West Dodge, is desirable to maintain water quality.

Considering the immediate need for water quality control provision of storage to assure that the streamflow is met 99 percent of the months or approximately 90 percent of the years is considered desirable. Storage necessary to maintain 3 cfs at each of the three sites and to supplant the natural flow has been estimated to be 1,080 acre-feet at Irvington, 1,680 acre-feet at West Dodge, and 600 acre-feet at County Line. These values do not include losses from evaporation and provision for sedimentation.

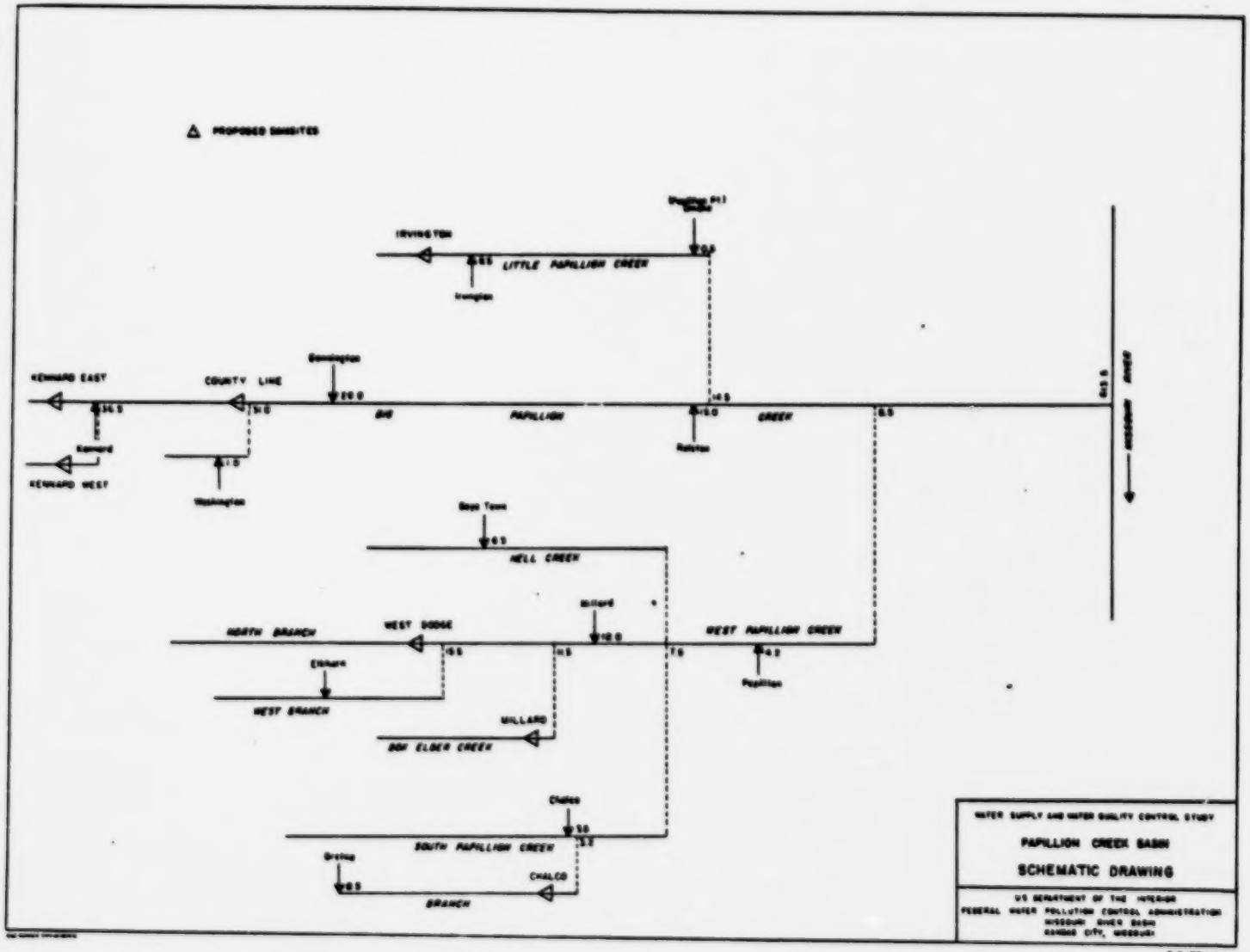

FIGURE VIII-1

IX. BENEFITS

Municipal and Industrial Water Supply

It is anticipated that future water needs can be most economically met through use of ground water in some areas and from the Missouri River through the Omaha Municipal Water District system, therefore, provision of storage for water supply purposes would not be of benefit to the study area.

Water Quality Control

Papillion Creek and its tributaries flow through areas that are, or in the future will be, intensely developed for residential and commercial use. Improvement of the land adjacent to streams, as parkways, is a part of the plan proposed by the Omaha City Planning Department.

Maintenance of flow in the streams through streamflow regulation could reduce or eliminate the occurrence of nuisance conditions. Provision of storage to maintain the selected quality objective of 5 mg/l dissolved oxygen would maintain approximately 60 miles of river for recreational use. Flow regulation should be considered an integral part of the water quality control program of the area. Removal of collectable wastes would reduce but not eliminate the need for flow regulation for water quality control.

The value of the benefits resulting from maintaining water quality in these streams is not directly measurable but may be evaluated in

terms of the most economical alternatives that could be used in the absence of multiple-purpose projects to accomplish the same purpose. Alternatives considered include (1) streamflow regulation by storage in a single purpose project, (2) waste collection and diversion (3) streamflow regulation by ground water pumping and (4) advanced waste treatment.

The construction of a reservoir or reservoirs needed to maintain flow for adequate dilution of all wastes that are expected in the Omaha area would be impractical. The collection and removal of wastes from the Papillion Basin in the Omaha metropolitan area for treatment and discharge to the Missouri River are considered a reasonable part of an adequate water quality control program.

Due to the importance of maintaining as good a quality of water as possible during the interim period, while an area collection and treatment system is being developed and as urban runoff becomes an increasingly important waste source in the area, the provision of storage for streamflow regulation can have considerable benefit.

Although the cost of construction of a single purpose reservoir and of purchasing water from the Omaha Municipal Water District were considered, the least costly alternative would be the construction of wells and pumping facilities at three locations where dilution water is required.

The cost of these facilities as computed by the Omaha District Corps of Engineers is as follows:

	Annual Costs		
	County Line	Irvington	West Dodge
Amortization of Initial Investment at 3-1/8 percent	$1,540	$1,016	$1,343
Operation and Maintenance	500	500	500
Replacement	679	421	582
Energy	604	1,440	1,300
Totals (Rounded)	$3,300	$3,400	$3,700

Grand Total for Basin - $10,400

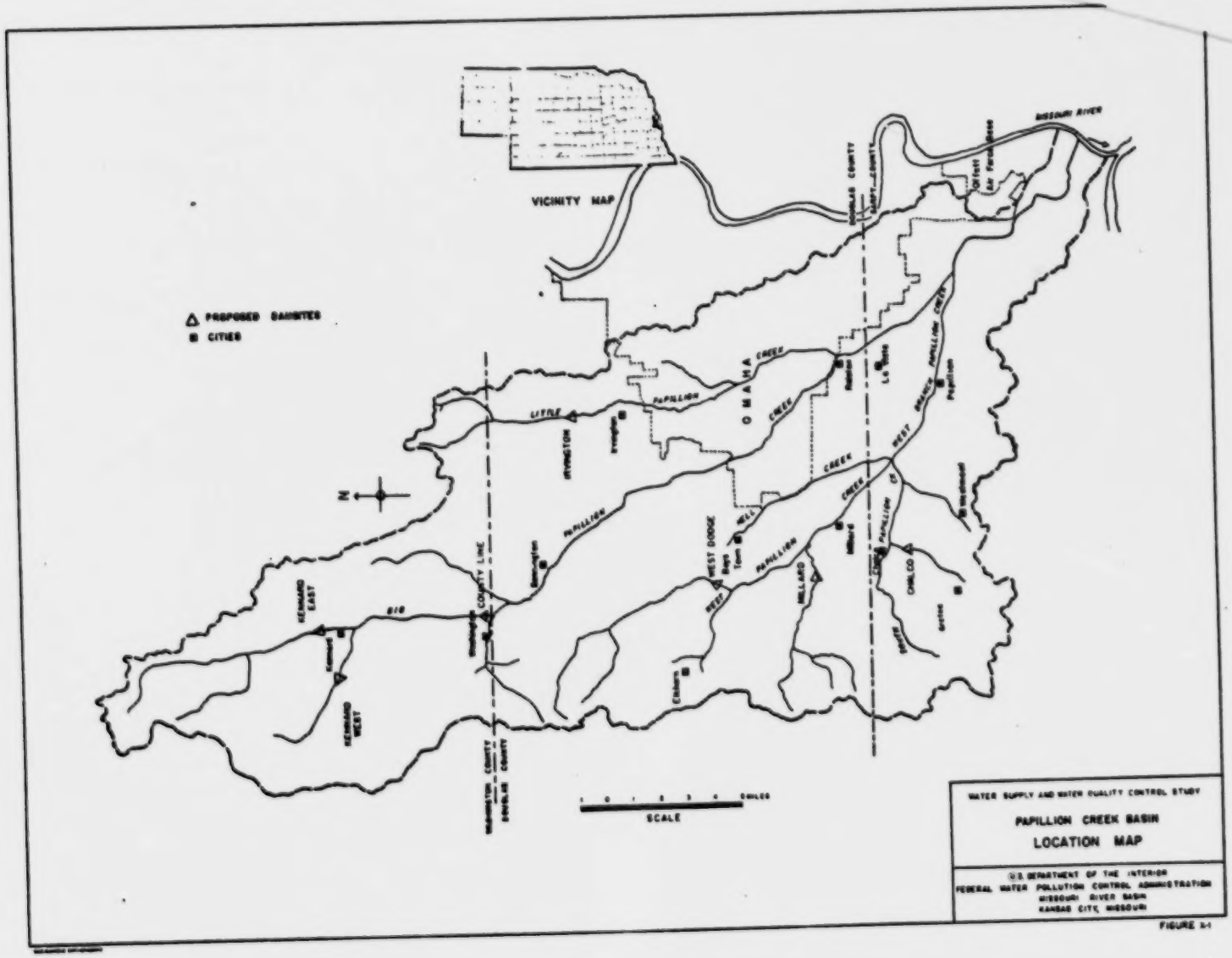
VICINITY MAP
PROPOSED DAMSITES
CITIES
MISSOURI RIVER
DOUGLAS COUNTY
SARPY COUNTY
OMAHA
CREEK
LITTLE PAPILLION
PAPILLION
CREEK
WEST PAPILLION CREEK
WASHINGTON COUNTY LINE
WASHINGTON COUNTY
DOUGLAS COUNTY
KENNARD EAST
KENNARD WEST
BLAIR
WEST DODGE
HILLARD
CHILCO
N
0 1 2 3 4 MILES
SCALE
WATER SUPPLY AND WATER QUALITY CONTROL STUDY
PAPILLION CREEK BASIN
LOCATION MAP
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MISSOURI RIVER BASIN
KANSAS CITY, MISSOURI

FIGURE A-1

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7. Department of Health, State of Nebraska, Chemical Analyses of Nebraska, Municipal Water Supplies, 1965.

APPENDIX

Exhibit No. 1

Municipal Water Supplies
Papillion Creek Basin, Nebraska[3/]

Location	Population Served 1960	Population Served 1963	Source of Supply	Water Treatment	Max. Dependable Draft (mgd)	Average Plant Output (mgd)	Estimated GPCD
Bennington	341	350	2 Wells	None	.200	.036	103
Boys Town	997	1,005	Omaha	-	-	1.1E	110E
Elkhorn	749	840	4 Wells	None	1.108	0.9E	110E
Gretna	745	750	2 Wells	None	.115	0.8E	110E
Kennard	331	335	2 Wells	None	.101	.017	51
Millard	1,014	2,000	3 Wells	None	.540	2.2E	110E
Omaha	301,598	303,305	Missouri River	Sedimentation, Softening, pH Control, Chlorination, Taste & Odor Control	No Limit	57.150	188
Papillion	2,235	2,630	4 Wells	None	.720	.275	104
Ralston	2,977	3,500	6 Wells	None	.850	.450	129

Exhibit No. 2

Chemical Analyses of Water Supplies
Papillion Creek Basin (Nebraska)1/

Community	Total Dissolved Solids	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Iron (Fe)	Hardness (as $CaCO_3$)	Source
Bennington	228	26	30	(1)	0.35	244	Ground Water
Elkhorn	326	7	11	(1)	0.05	262	Ground Water
Kennard	458	16	8	(1)	.47	396	Ground Water
Mead	460	18	44	(1)	2.25	272	Ground Water
Millard	270	7	9	(1)	0.06	268	Ground Water
Omaha	373	15	181	(1)	(2)	153	Missouri River
Papillion	290	7	32	(1)	0.0	220	Ground Water

Results shown in parts per million (milligrams per liter).
(1) Less than 10 mg/l nitrate-nitrogen
(2) Less than 0.03 mg/l iron

Exhibit No. 3

Basic Data on Sources of Pollution
Papillion Creek Basin (Nebraska)[27]

Location	River Miles Above Mouth	Population 1960	Sewered	P. E. Before Tr.	Type of Waste	Treatment Provided	P. E. Discharged	Watercourse
WASHINGTON CO.								
Kennard	M 613.5-36.5	331	300	300	Domestic	None	300E	Big Papillion Creek
DOUGLAS CO.								
Omaha (Papillion Pt.)	M 613.5-14.5-0.5	60,000		90,000	Domestic & Industrial	Secondary	13,500E	Little Papillion Cr.
Bennington	M 613.5-28.0	341	330	330	Domestic	Lagoon	33E	Big Papillion Creek
Elkhorn	M 613.5-8.5-15.5-4.2	749	1,000	1,000	Domestic	Secondary	150E	West Branch of West Papillion Cr.
Boys Town	M 613.5-8.5-7.5-6.5	997	990	990	Domestic	Secondary	150E	Hell Creek to West Papillion Cr.
Millard	M 613.5-8.5-10.0	1,014	3,000	3,000	Domestic	Secondary	450E	West Papillion Cr.
Papillion	M 613.5-8.5-4.2	2,235	2,000	2,000	Domestic	None	2,000E	West Papillion Cr.
East Sarpy Co. S&ID		10,000		2,500	Domestic	Secondary	375E	Papillion Cr.

E - Estimated